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Triple-level degenerative spondylolisthesis and the importance of spinopelvic parameters: Case report

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ABSTRACT

Background: Lumbar degenerative spondylolisthesis typically occurs at a single vertebral level and infrequently at two separate levels. However, a triple level lumbar degenerative anterolisthesis is an extremely rare clinical scenario.

The preservation or restoration of sagittal balance with the consideration of the observed spinopelvic parameters is of a cardinal importance in multilevel level DS than in single level DS.

Presentation of the case: An evaluation of a middle-aged woman with persistent radiculopathy and neurogenic claudication revealed a three-level degenerative anterolisthesis from L3 to S1. With the placement of Iliac to L3 screw rod fixation in association with a decompressive laminectomy, a three-level interbody fusion and three level Smith Petersen osteotomies; a desirable lordosis and sagittal balance was preserved. She is ambulating well at a 9-month follow-up encounter.

Conclusion: Three level continuous degenerative anterior spondylolisthesis of the lumbar spine is a very rare clinical scenario being reported in only one previous instance throughout medical literature. The key initiative in the management of this condition is the preservation or correction of any sagittal imbalance present.

1. Introduction

Single-level degenerative spondylolisthesis (DS) is a common pathology which occurs in almost 10% of all individuals [1-3]. However, 2-level degenerative anterolisthesis is less common and a triple-level DS with forward slippage of three continuous lumbar vertebra is quite rare [4-7]. Moo et al. reported the first example of a triple–level degenerative anterolisthesis in 2015 [8]. The current case is the second reported instance; though there certainly exist cases which have yet to be reported within medical literature.

Management of symptomatic multilevel DS is a matter of debate for which different strategies have evolved over time. These have included the utilization of a laminectomy, laminectomy with posterolateral fusion, and a laminectomy plus instrumentation, interbody fusion and even osteotomy. Recently, the notable occurrence of sagittal imbalance in long lasting multilevel degenerative spondylolisthesis has been highlighted within the literature.

Herein, we present a middle-aged woman with this particular pathology who was successfully managed.

2. Presentation of the case

A 58-year-old woman was referred to our department with a chief complaint of lower back pain and left lower limb radiculopathy for 3 months duration. She had history of tolerable lower back and calve pain with a feeling of numbness while walking for a distance of about 500 m. This was found to be compatible with neurogenic claudication or intermittent spinal claudication. However, after 10 min of rest and while in a seated position, her symptoms would suddenly remit and she was able to ambulate normally. Neurological examination subsequently revealed decrease of strength score of 3/5 on dorsiflexion of the left foot.

A lateral standing radiograph showed a balanced spine with a three-level degenerative anterolisthesis from S1 to L3. Lumbar lordosis (LL:68) was more enough than pelvic incidence (PI:56) indicating sagittal

Abbreviations: BMI, Body mass index; DS, Degenerative spondylolisthesis; LL, Lumbar Lordosis; PI, Pelvic Incidence; SS, Sacral slope; SPI, Smith Peterson osteotomy; SVA, Sagittal vertical axis; TLIF, Transforaminal lumbar interbody fusion.

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balance. The sum of sacral slope (SS: 34) and pelvic tilt (PT:22) was equal to pelvic incidence (PI:56) There were also degenerative changes and a decreased disc space noted at the L5-S1 spinal level. An AP lumbar spine X-ray displayed an 18-degree degenerative lumbar scoliosis (Fig. 1a & 1b). Flexion extension lumbosacral x-ray clearly depicted a mild increase in the degree of slippage at all three vertebral levels (Fig. 1c & 1d). Magnetic resonance imaging (MRI) revealed degenerative changes with additional Modic changes and grade one slippage at the L5-S1 level (Fig. 2).

2.1. Surgical technique

The patient underwent iliac to L3 screw rod instrumentation and three-level TLIF in association with a three-level Smith Petersen osteotomy. In total spine radiographs taken at a 3-month follow up encounter, correction of the scoliosis from 18 to 3degree and preservation of the sagittal balance with demonstration of sagittal vertical axis (SVA) were demonstrated (Fig. 3). Lordosis remained more than pelvic incidence as well. At 11 months she is now doing quite well and claims that the surgical intervention met all her expectations (compatible with point 1 of NASS 4-point satisfaction scale).

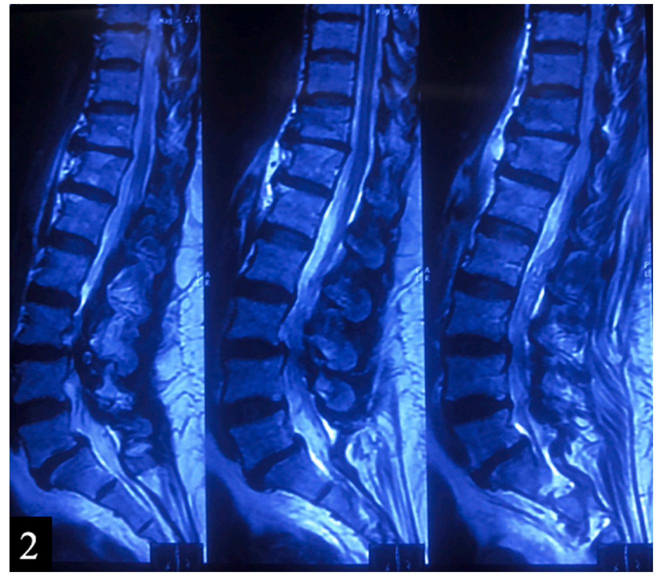

Fig. 2. Sagittal 2- weight MRI shows multilevel compression on the theca.

3. Discussion

Degenerative spondylolisthesis (DS) is an acquired condition with the forward displacement of a lumbar vertebra or a caudal vertebra; without a disruption of the pars interarticularis [1–3]. It is often associated with the degenerative changes of aging such as progressive intervertebral disc-facet joints degeneration, hypertrophy of the ligamentum flavum, and the buckling and encroachment of the osteophytes into the spinal canal or foramina which may result in central and lateral recess stenosis.

3.1. Incidence

Risk factors for DS include older age, female gender, larger body mass index (BMI), sacralization of the L5 vertebra, and the sagittal orientation of the corresponding facet joints [9–14]. Biomechanically, lumbar facet joints with normal orientation share loads in both compression and extension. They also control anterior shear forces. However, the facet joints with an observed sagittal orientation are not able to control the shear forces and this in turn facilitates the phenomenon referred to as slippage [9–14]. In several studies significant sagittal orientations have been discovered. In particular, within the facet joints of the L4-L5 level. This then serves to explain the higher observed frequency of DS at this particular vertebral level [10–12].

Recent studies have served to illuminate the relationship between DS and its high pelvic incidence (PI) [15].

As increased PI is associated with a high sacral slope (SS); both parameters are understood to play pivotal roles in the pathogenesis of lumbar DS [15]. According to Schuler et al, a high PI and SS cause lumbar lordosis. The latter of the two results in increased constraints on the facet joints and causes shearing forces on the lumbar discs. All such collective factors affect the corresponding lumbar spines functional unit leading to the development of DS.

The progression of the vertebral slippages may gradually cause local kyphosis and loss of local lumbar lordosis. With an increase in the magnitude of local kyphosis over time, the vertebral column tends to shift forward [15]. Initially, the compensatory mechanisms including thoracic flattening, pelvic retroversion, and knee flexion will continuously try to maintain the erect position of the spine. Ultimately with the

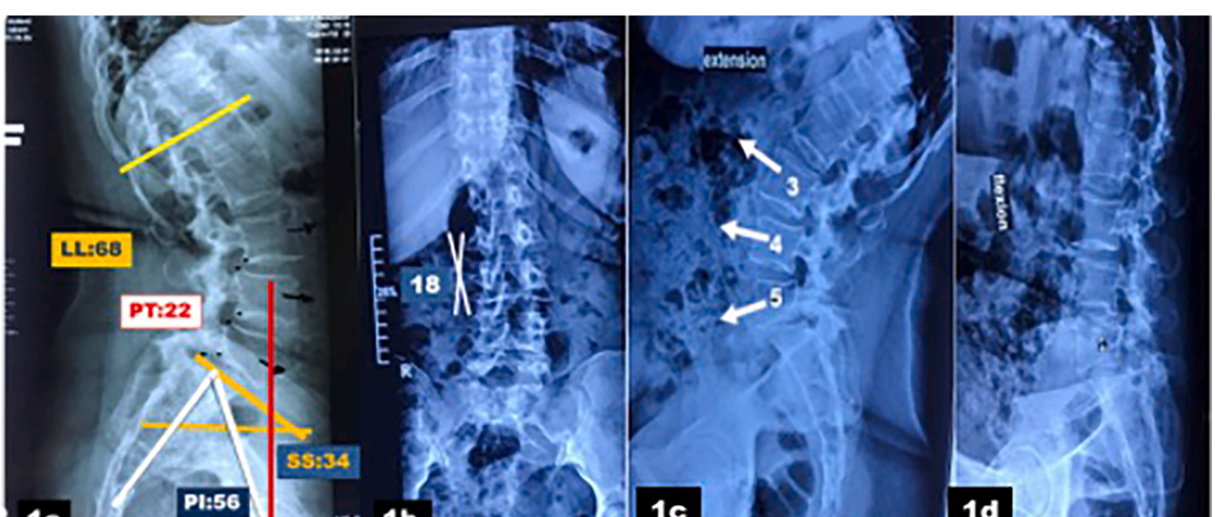

Fig. 1. Lumbosacral plain and dynamic radiographs (a) lateral view, indicate physiologic type III, with pelvic incidence (PI) of 56, sacral slop (SS) 34degree, pelvic tilt (PT) 22 degree and 68-degree lumbar lordosis (LL). Note three level degenerative spondylolisthesis more prominent at L5-S1level (b) AP view shows degenerative scoliosis of 18 degree. (c) in extension (d) in flexion.

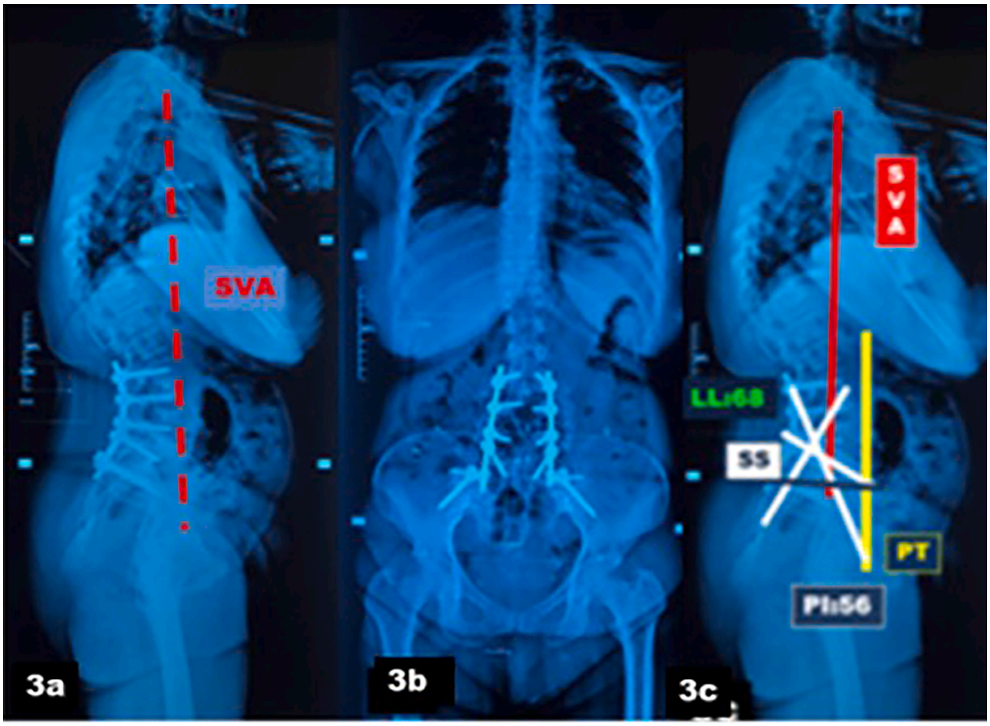

Fig. 3. Post-operative total spine radiographs. (a) Lateral view shows a balanced spine with normal sagittal vertical axis (SVA), (b) AP view shows good coronal alignment, (c) sacropelvic parameters; pelvic incidence (PI) 56 degree and lumbar lordosis (LL) 68-degree, sacral slope 36 and PT 20 degree which are all in normal limits.

failure of these provisions, the center of gravity shifts forward and sagittal imbalance occurs [15].

In the setting of DS, with progression of the disease, sagittal imbalance with anterior shift of the trunk appears in up to 24% of cases according to Ferrero et al. [16]. However, an additional 40% of cases surveyed by Ferrero et al. showed compensation with pelvic retroversion. This indicates the possible development of sagittal imbalance in the upcoming years after failure of this compensatory mechanism [16,17]. Eventually, the scenario of sagittal imbalance tends to occur earlier and of more intensity in two level DS and triple level DS, with respect to accumulation of the shearing forces [16,17].

3.2. Clinical picture

A patient with multilevel DS may remain asymptomatic for several years. However, in symptomatic patients, the disease begins with lower back pain [4–9]. As the disease progresses, the appearance of local stenosis, radiculopathy, or neurogenic claudication may manifest [4–9]. Sexual dysfunction and urinary disturbances are uncommon in lumbar DS. This is true only if the condition is not associated with severe canal stenosis.

Local static and functional standing lumbosacral radiographs are the first imaging tool which should be utilized in a patient with lower back pain with or without radiculopathy present. The intensity and number of slipped vertebras can be best assessed in lateral dynamic radiographs [4–-9]. The percentage of the slippage at each level can be measured according to Meyerding's technique.

3.3. Imaging

Total spine standing radiographs are of great importance in the demonstration of sagittal and coronal balance as well as for spinopelvic parameters and should be undertaken in all patients with confirmed DS [16,17]. Sagittal alignment can be assessed with sagittal vertical axis and C7 tilt.

Sagittal vertical axis (SVA) is the most useful technique in the evaluation of sagittal balance. SVA is defined as the horizontal offset from the posterosuperior corner of S1 to the C7 plumb line. The distance of SVA from the posterior corner of the first sacral vertebra (S1) below 4 cm is regarded normal [16–24]. Anterior shift beyond 4 cm is designated as positive sagittal imbalance. However, this may increase with age for example after 50 years old it becomes 4. 1±8 mm. C7 sacrum tilt (C7 S-tilt) is the angle between the perpendicular line to the mid- point of superior S1 endplate and the line drawn from the center of C7 to the center of the superior endplate of S1 [16–24]. Another parameter that can analyze mal-alignment considering the spine and the pelvis simultaneously is global tilt (GT). GT is an angle formed by the intersection of two lines, the first line is drawn from the center of C7 to the center of the sacral endplate (C7 ST) and the second line is drawn from the center of the femoral heads to the center of the sacral endplate and its mean is 23. 2 degree in middle age asymptomatic subjects [16–24]. From geometrical point of view, GT equals the sum of the pelvic tilt (PT) and the C7 vertical tilt (C7 VT). Where SVA and PT are significantly influenced by patient positioning, global tilt (GT) shows no significant change with position of the patient. Other important lines include lumbar lordosis or LL (defined as the angle between the upper L1 endplate and the upper sacral endplate, with mean of 57.2° ± 13), thoracic kyphosis or TK (defined as the angle between the upper T4 endplate and the upper T12 endplate) pelvic incidence or PI (defined as the angle between the perpendicular line to the upper sacral endplate at its midpoint and the line connecting this point to the femoral head axis with mean of 49.6+_12.1. Sacral slope or SS (defined as the angle between the horizontal line and the upper sacral endplate), pelvic tilt or PT (defined by the angle between the vertical line and the line through the midpoint of the sacral plate to the femoral head axis (Figure 6a) [16–24].

T1 pelvic tilt (T1PT) and T1 sagittal tilt (T1ST) are new parameters used for imbalance (Figure 6b). (T1PT) is defined as an angle between the line from the femoral head axis to the center of T1 and the line from the femoral head axis to the middle of the S1 superior end plate with mean of 8.6° ± 8. 5 after 50 years old; T1ST is defined as the angle between a line drawn from the center of the femoral head axis to the midpoint of the T1 vertebral body and the vertical line, with mean $-1.35^{\circ} \pm 2.7$. Femoral shaft angle (FA) results from knee flexion as a compensatory mechanism and is defined as the angle between the vertical line and the line along the shaft of femur.

MRI can depict associated herniated disc and the degree of thecal sac or foraminal compromise respectively.

3.4. Treatment

Historically the treatment of symptomatic DS has long been a topic of debate and both conservative and surgical managements have been proposed. However, most of the surveys have shown the superiority of surgical management over the conservative treatment in patients with symptomatic lumbar DS [25–28]. However, all studies indicate that surgical intervention should be performed only after conservative attempts have failed.

In multilevel DS, in patients with gross spinal imbalance and in those with subtle compensated balance; spinopelvic parameters should be given sufficient consideration. Ignoring these two scenarios will undoubtedly influence the surgical outcome [29,30]. In such cases, lumbar lordosis equal to or 9 degree more than the sum of the pelvic incidence and femoral angle (FA) should be obtained. This can be usually achieved with a decompressive laminectomy, osteosynthesis, and a multilevel transforaminal lumbar interbody fusion (TLIF) [15,31–36]. If optimal LL could not be obtained with this strategy, optimal lumbar lordosis with restoration of sagittal balance might be obtained with an additional multilevel Smith Peterson osteotomy (SPO) and even pedicle subtraction osteotomy (PSO) [31].

3.5. Outcome

The Spine Patients Outcomes Research Trial (SPORT) group has shown the superiority of surgical management over the conservative treatment in the patients with symptomatic lumbar DS [37]. Weinstein et al, in compare of non-operatively treated patients with DS in association with canal stenosis and the surgically treated similar patients found substantially greater pain relief and functionally more improvement in the latter group [38].

Later, the studies focused only on the results of partial or complete reduction of the deformity, osteosynthesis and bony fusion [39].

Hopefully, the importance of sagittal balance and sacropelvic parameters in the surgical management of lumbar spondylolisthesis paid more attention with time [15,29–36,40–42].

Recently, postoperative clinical and radiological surveys of the patients with lumbar spondylolisthesis have indicated that acceptable short- and long-term outcomes can be only achieved with consideration of any coexisting sagittal deformity and its correction [41,42].

This first began with attempts to correlate postoperative spinopelvic parameters with health-related quality of life (HRQOL) in isthmic spondylolisthesis [32,33]. Later, the authors focused on the outcome of the surgically treated patients with DS and discovered high levels of correlation between the patient satisfaction and the preservation or restoration of spinal balance. [15,34–36,41].

It should be reminded that the consequences of sagittal imbalance are a gradual bending posture, loosening or pull out of the screws, pseudarthrosis, and proximal junction disease or failure. If we consider that each of these complications will ultimately require challenging revision surgeries, the importance of restoration of sagittal balance is emphasized.

Two separate studies identified that postoperative spinopelvic parameters correlate with health-related quality of life (HRQOL) in isthmic spondylolisthesis [31–33]. According to their studies, the key radiographic parameter that correlate with patient pain, disability and ultimate outcome is pelvic tilt (PT).

Later, several other studies focused on the outcome of the surgically treated patients with single or 2-level DS and found that preservation or restoration of spinal balance correlate with high level of satisfaction [7,41,42].

4. Conclusion

In a patient with multilevel DS with sagittal imbalance or balanced with compensatory mechanisms; the cardinal benefit of the consideration of spinopelvic parameters in association restoration or preservation of sagittal balance is the overall patient's satisfaction. Patient-reported outcomes (PROs) questioner and the North American Spine Society NASS 4-point satisfaction scale are gaining a central role in evaluating the effectiveness of surgical interventions and the necessary changes in the treatment trajectory.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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